



Single-port transaxillary robotic thyroidectomy and lateral neck dissection: technique, early outcomes, and neuromonitoring

Kwangsoon Kim

Department of Surgery, College of Medicine, The Catholic University of Korea, Seoul, Republic of Korea

Therapeutic lateral neck dissection is recommended for papillary thyroid carcinoma with clinically evident lateral cervical lymph node metastasis (N1b). Conventional open surgery provides reliable oncologic outcomes but leaves a cervical scar. Remote-access robotic surgery was introduced to avoid a visible neck incision, with subsequent studies reporting comparable lymph node yields. The da Vinci single-port (SP) system delivers wristed instruments and a flexible three-dimensional endoscope through a single 2.5-cm cannula. Early clinical series from experienced Korean centers have reported lateral lymph node yields and short-term complication rates comparable to those of multiport robotic and open approaches, though operative time was initially longer. Intraoperative neuromonitoring (IONM) using the V1–R1–R2–V2 protocol may facilitate recurrent laryngeal nerve identification and functional assessment, while extended stimulation may aid assessment of the spinal accessory and phrenic nerves during lateral neck dissection. However, current evidence remains limited to small, predominantly single-center retrospective series, and no SP-specific IONM outcome data are currently available. Prospective multicenter studies with long-term oncologic follow-up are needed before broader adoption of this technique can be recommended.

Key words Robotic surgical procedures, Thyroid neoplasms, Neck dissection, Intraoperative monitoring, Thyroidectomy

Introduction

Clinically evident lateral cervical lymph node metastasis is less frequent than central compartment disease in papillary thyroid carcinoma (PTC), but it carries important surgical implications. The 2015 and 2025 American Thyroid Association (ATA) guidelines recommend therapeutic lateral neck dissection for biopsy-proven N1b disease, while the 2012 ATA surgical affairs committee consensus statement clarifies the typical compartment-oriented extent, including levels IIa, III, IV, and Vb [1–3].

Open modified radical neck dissection (MRND) remains the standard approach. While it affords direct access and well-documented long-term oncologic safety, it produces a transverse cervical incision that

may negatively affect patient satisfaction with neck appearance. Kim et al. [4] demonstrated in a multicenter randomized controlled trial that cervical scar outcomes after conventional thyroidectomy are measurably affected by wound management technique, underscoring the cosmetic relevance of surgical access.

Remote-access surgery was introduced as a way to avoid a visible cervical incision while maintaining access to the central and lateral neck compartments. Kang et al. [5] reported the first large series of robotic transaxillary thyroidectomy using the da Vinci system in 2009, and by 2022, Kim et al. [6] had accumulated experience with robotic transaxillary lateral neck dissection in over 500 patients. Meanwhile, bilateral axillo-breast approach (BABA) robotic MRND was reported by Choi and Kang [7] in 2017. The da

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Corresponding to Kwangsoon Kim

E-mail. noar99@naver.com **ORCID.** <https://orcid.org/0000-0001-6403-6035>

Vinci single-port (SP) system was later adapted for transaxillary thyroidectomy and, subsequently, lateral neck dissection.

This narrative review examines the current evidence on SP transaxillary robotic lateral neck dissection using the da Vinci SP system, describes the published surgical techniques, and discusses the role of intraoperative neuromonitoring (IONM) in this setting.

The da Vinci Single-Port System: Technical Features and Regulatory Status

The SP platform is distinguished by its single-cannula configuration [8,9]. Three semi-rigid, fully wristed instruments and a flexible three-dimensional high-definition endoscope are introduced through one 2.5-cm cannula (Intuitive Surgical, Inc.). Each instrument arm has multiple joints that enable triangulation within the operative field, and the endoscope itself is fully articulated, allowing the surgeon to adjust the viewing angle independently of the instruments. The “relocation” function permits repositioning of the instrument cluster toward a new target zone within the same operative field, which is particularly useful when transitioning from thyroidectomy to lateral neck dissection.

The da Vinci SP system received initial U.S. Food and Drug Administration (FDA) 510(k) clearance for SP urologic surgical procedures in May 2018 (K173906) [8]. In March 2019, a supplemental clearance (K182371) expanded the indications to include transoral otolaryngology surgical procedures in the oropharynx, restricted to benign tumors and malignant tumors classified as T1 and T2 [9]. Intuitive Surgical issued a press release describing this transoral clearance [10]. Both clearance documents state that safety and effectiveness for general laparoscopic procedures

have not been established [8,9]. Transaxillary thyroidectomy and lateral neck dissection are not among the FDA-cleared indications, and their use with the SP system therefore constitutes off-label application.

The current SP platform also has practical limitations. In the published SP thyroid and neck dissection series, the lack of a robotic ultrasonic energy device for the SP cannula has been cited as a practical limitation; surgeons may rely on monopolar and bipolar energy or use conventional energy instruments through an auxiliary port. Counter-traction depends on assistant-held instruments introduced through an auxiliary port. Workspace constraints may be encountered during dissection of level IV near the clavicle, and, in gas-insufflation approaches, CO₂ management requires additional attention. The technical characteristics, regulatory status, and practical limitations of the da Vinci SP system in transaxillary thyroid and lateral neck surgery are summarized in Table 1.

Evolution of Robotic Approaches to Lateral Neck Dissection

Robotic transaxillary thyroidectomy was first applied clinically by Kang et al. [5] in 2007, and the initial 100-case series was published in 2009. Extension of the transaxillary approach to lateral neck compartments followed, with Kang and Chung [11] reporting the first robotic MRND in 2015. Kim et al. [12] subsequently published a 5-year comparative assessment of transaxillary robotic versus open MRND in 193 N1b PTC patients, demonstrating comparable recurrence rates and stimulated thyroglobulin levels over a median follow-up of 66 months.

In a 500-case series, robotic transaxillary lateral neck dissection was completed without open conversion and showed acceptable operative and oncologic outcomes in a high-volume center [6]. This

Table 1. Key features and limitations of the da Vinci SP system in transaxillary thyroid and lateral neck surgery

Category	Key features or status	Clinical implication	References
Platform configuration	Three wristed instruments and a flexible 3D endoscope are introduced through a single 2.5-cm cannula	Enables single-cannula remote-access surgery through an axillary incision, reducing the number of robotic access ports compared with multiport systems	[8,9,13–16]
Instrument articulation	Semi-rigid wristed instruments with multiple joints allow internal triangulation	Facilitates dissection in a narrow working space, including the central neck and lateral neck compartments	[13–16,19,20]
Flexible endoscope	The articulated 3D endoscope can be repositioned independently of the instruments	Improves visualization when moving between the thyroid bed and lateral neck compartments	[8,9,13–16]
Relocation function	The instrument cluster can be redirected toward a new target zone within the same operative field	Useful when transitioning from thyroidectomy or central neck dissection to lateral neck dissection through the same axillary access	[13–16,19,20]
Regulatory clearance	FDA 510(k) clearance was granted for single-port urologic procedures in 2018 and expanded to selected transoral otolaryngology procedures in 2019	Transaxillary thyroidectomy and lateral neck dissection are not FDA-cleared indications and represent off-label use of the SP system	[8–10]
Energy device limitation	A dedicated robotic ultrasonic energy device for the SP cannula has not been available in reported thyroid and neck dissection series	Surgeons may rely on monopolar and bipolar robotic energy or use conventional energy devices through an auxiliary port	[13–16,19,20]
Assistant role	An auxiliary port is commonly used for suction, clipping, counter-traction, or conventional instrumentation	SP transaxillary surgery is not entirely single-port in practice and requires coordinated bedside assistance	[19,20]
Working space	Gasless retraction or low-pressure CO ₂ insufflation can be used to maintain the operative field	The gasless STAR-RND and gas-insufflation GOSTA-RND techniques differ in workspace creation but share similar lateral neck dissection targets	[19,20]
Lower lateral neck limitation	Dissection near level IV and the clavicle may be restricted by the narrow transaxillary working corridor	Careful case selection and surgeon experience are important, particularly for lower lateral neck disease	[19,20]
CO ₂ -related considerations	Gas-insufflation approaches use low-pressure CO ₂ , reported at 5–8 mmHg in GOSTA-RND	Requires monitoring for potential CO ₂ -related issues such as subcutaneous emphysema or hemodynamic effects	[20]
Evidence limitation	Current clinical evidence is limited to early series from experienced centers	The platform appears technically feasible, but long-term oncologic outcomes, cost-effectiveness, and broader reproducibility remain insufficiently established	[13–20]

SP, single-port; CO₂, carbon dioxide; 3D, three-dimensional; FDA, U.S. Food and Drug Administration; STAR-RND, single-port transaxillary robotic neck dissection; GOSTA-RND, gas-insufflation one-step single-port transaxillary robotic neck dissection.

multiport experience supported the feasibility of comprehensive lateral compartment dissection through a remote-access route and laid the groundwork for subsequent SP applications.

The SP platform was first applied to transaxillary hemithyroidectomy by Kim et al. [13] in 2020, and the experience was subsequently expanded to larger thyroidectomy series, providing the technical foundation for SP lateral neck dissection [14–16]. Park et al. [16] reported a learning curve of approximately 20 cases for SP transaxillary lobectomy in surgeons with prior robotic experience. Kim [17] provided a com-

prehensive review of the evolution and clinical impact of SP transaxillary robotic thyroidectomy in 2025. Experience with SP robotic areolar-MRND remains limited to a single small series, whereas the transaxillary approach has relatively more clinical data [18]. The evolution of robotic approaches to lateral neck dissection and the current position of SP transaxillary robotic lateral neck dissection are summarized in Table 2.

Table 2. Evolution of robotic lateral neck dissection approaches

Stage	Representative studies or period	Surgical approach	Key contribution	Current evidence and limitations
Conventional open MRND	Established standard approach; ATA guidelines and consensus statement [1–3]	Direct cervical access through a transverse neck incision	Provides reliable exposure of the lateral neck compartments and well-documented long-term oncologic outcomes	Remains the standard approach, but leaves a visible cervical scar that may affect patient satisfaction
Multiport transaxillary robotic MRND	Kang et al. [5]; Kang and Chung [11]; Kim et al. [6,12]	Remote-access transaxillary approach using multiport robotic systems	Established the feasibility of comprehensive lateral neck dissection through an axillary route and demonstrated acceptable lymph node yields and oncologic outcomes in experienced centers	Evidence includes relatively large retrospective series, but outcomes are mainly from high-volume Korean centers
BABA robotic MRND	Choi and Kang [7]	BABA	Expanded remote-access robotic options for MRND	Less commonly used for lateral neck dissection than the transaxillary approach; evidence remains limited
SP transaxillary robotic thyroidectomy	Kim et al. [13]; Kim [17]; Kang et al. [14]; An et al. [15]; Park et al. [16]	SP transaxillary approach using the da Vinci SP system	Provided the technical foundation for SP-based remote-access thyroid surgery, including single-cannula access, wristed instruments, and a flexible 3D endoscope	Increasing short-term experience for thyroidectomy, but data are not specific to lateral neck dissection
SP transaxillary robotic lateral neck dissection	Ho et al. [19]; Chang et al. [20]	STAR-RND using a gasless approach; GOSTA-RND using gas insufflation	Demonstrated early feasibility of SP transaxillary lateral neck dissection, with reported lymph node yields and short-term complication profiles comparable to open or multiport approaches in selected patients	Evidence is limited to small, retrospective, single-center series with short follow-up
Related SP remote-access MRND	Shin et al. [18]	SPRA approach with MRND	Shows that SP-based MRND can be extended beyond the transaxillary route	Early experience only; not directly equivalent to SP transaxillary lateral neck dissection
Current status	Present review; remote-access IONM experience from Ji et al. [24]	SP transaxillary robotic lateral neck dissection in selected patients	Potential cosmetic advantage by avoiding a cervical scar while maintaining access to central and lateral neck compartments	Long-term oncologic outcomes, patient-reported outcomes, cost-effectiveness, and SP-specific IONM outcome data remain insufficient; current use should be limited to selected patients in experienced centers

MRND, modified radical neck dissection; BABA, bilateral axillo-breast approach; SP, single-port; ATA, American Thyroid Association; 3D, three-dimensional; STAR-RND, single-port transaxillary robotic neck dissection; GOSTA-RND, gas-insufflation one-step single-port transaxillary robotic neck dissection; SPRA, single-port robotic areolar; IONM, intraoperative neuromonitoring.

Surgical Technique for Single-Port Transaxillary Lateral Neck Dissection

The published SP transaxillary MRND techniques can be broadly divided into gasless and gas-insufflation approaches.

1. STAR-RND (gasless approach)

Ho et al. [19] described a gasless technique using an axillary skin incision (4–6 cm), through which a

subcutaneous and subplatysmal flap is elevated over the sternocleidomastoid muscle to the lateral neck. An external retractor system maintains the working space. The SP cannula is introduced through the axillary incision, and dissection proceeds in a caudal-to-cranial sequence: level IV and Vb first, then level III, and finally level IIa and IIb. The spinal accessory and phrenic nerves are identified during lateral neck dissection, while the vagus nerve and recurrent laryngeal nerve (RLN) are assessed during thyroidectomy and central neck dissection when performed concurrently. An auxiliary 5-mm trocar accommodates suction and clip applier instruments

controlled by the bedside assistant. When thyroidectomy is performed concurrently, the same axillary access is used, and the relocation function allows the instrument cluster to be shifted medially [19].

2. GOSTA-RND (gas-insufflation approach)

Chang et al. [20] described a gas-insufflation one-step SP transaxillary approach in which a glove port is used to create a sealed access through the axillary incision. Low-pressure CO₂ insufflation (5–8 mmHg) is applied to maintain the operative space. The dissection sequence and anatomic targets are similar to those of the STAR-RND (single-port transaxillary robotic neck dissection). The gas-insufflation technique may reduce the need for external retraction and provide a more stable operative field, though CO₂-related considerations (subcutaneous emphysema, hemodynamic effects) require monitoring [20].

In both approaches, the articulating SP instruments are used to dissect the lateral neck through a remote axillary access. Both employ a bedside assistant for tasks that cannot be performed robotically.

Early Clinical Outcomes of Single-Port Transaxillary Lateral Neck Dissection

In the STAR-RND series of 30 patients, mean lateral lymph node yield was 34.6, with no permanent nerve injury, hypoparathyroidism, or major vascular injury [19]. In the GOSTA-RND (gas-insufflation one-step single-port transaxillary robotic neck dissection) comparative series (30 robotic vs. 39 open), lateral lymph node yields and complication profiles were similar, though early robotic cases required longer operative time [20]. With increasing experience, operative time for the lateral dissection component

was reported to decrease substantially.

At present, published clinical data on SP-based lateral neck dissection are limited to these early series. Although the short-term results suggest feasibility, several limitations remain. All data come from single Korean centers with extensive prior robotic thyroid surgery experience. Patient cohorts are small and retrospectively analyzed. Follow-up is insufficient to draw conclusions about long-term recurrence rates or disease-specific survival. Selection criteria generally favor patients with favorable body habitus and limited disease burden. Therefore, SP transaxillary lateral neck dissection should currently be limited to carefully selected patients and performed in experienced centers with substantial expertise in robotic thyroid surgery. The findings should be interpreted as evidence of technical feasibility and early safety rather than definitive proof of oncologic equivalence. Published clinical evidence on SP robotic thyroidectomy, SP transaxillary lateral neck dissection, and remote-access IONM is summarized in Table 3.

Intraoperative Neuromonitoring in Robotic Lateral Neck Dissection

In robotic lateral neck dissection, neural preservation is a central technical concern. The confined, remote operative field and the absence of direct tactile feedback make visual identification of nerves more challenging than in open surgery. IONM provides an adjunctive means of confirming nerve identity and assessing functional status during dissection.

The standard IONM protocol (V1–R1–R2–V2) was originally developed and validated for RLN monitoring during open thyroidectomy [21]. In this protocol, the vagus nerve is stimulated before (V1) and after (V2) thyroid resection, and the RLN is stimulated before

Table 3. Published clinical evidence on SP robotic thyroidectomy and lateral neck dissection

Study	Procedure or approach	Study population	Main findings	Key limitations
Kim et al. [13]	SP transaxillary hemithyroidectomy	Initial 10 consecutive cases	Demonstrated the initial clinical feasibility of SP transaxillary robotic thyroidectomy using the da Vinci SP system	Very small initial experience; thyroidectomy only, without lateral neck dissection
Kang et al. [14]	SP transaxillary robotic thyroidectomy	Consecutive 100 cases	Supported the safety and feasibility of SP transaxillary robotic thyroidectomy in an experienced center	Short-term surgical outcomes; not specific to lateral neck dissection
Park et al. [16]	SP transaxillary robotic lobectomy	Initial 50 lobectomy cases	Reported a learning curve of approximately 20 cases in surgeons with prior robotic experience	Focused on lobectomy; learning curve may not directly apply to lateral neck dissection
An et al. [15]	SP transaxillary robot-assisted thyroidectomy	Consecutive 300 patients	Provided larger short-term experience supporting the safety and surgical feasibility of SP transaxillary thyroidectomy	Thyroidectomy-focused series; oncologic and lateral neck dissection outcomes not directly addressed
Ho et al. [19]	STAR-RND, gasless SP transaxillary robotic MRND	30 patients	Reported a mean lateral lymph node yield of 34.6, with no permanent nerve injury, hypoparathyroidism, or major vascular injury	Small retrospective single-center series; short follow-up; performed in an experienced Korean center
Chang et al. [20]	GOSTA-RND, gas-insufflation SP transaxillary robotic MRND	30 robotic patients compared with 39 open patients	Reported similar lateral lymph node yields and complication profiles compared with open surgery; early robotic cases required longer operative time, which decreased with experience	Early comparative experience; retrospective design; limited long-term oncologic follow-up
Shin et al. [18]	SP robotic areolar thyroidectomy and MRND	Initial SPRA experience	Demonstrated that SP-based MRND can be extended beyond the transaxillary route	Related SP remote-access approach, but not directly equivalent to SP transaxillary lateral neck dissection
Ji et al. [24]	IONM in remote-access robotic and endoscopic thyroidectomy	Remote-access robotic and endoscopic thyroidectomy cases	Showed that IONM is feasible in remote-access thyroid surgery, although complete standardized monitoring can be more challenging than in open surgery	Not specific to the da Vinci SP system or SP transaxillary lateral neck dissection; recommendations must be extrapolated from non-SP experience

SP, single-port; STAR-RND, single-port transaxillary robotic neck dissection; MRND, modified radical neck dissection; GOSTA-RND, gas-insufflation one-step single-port transaxillary robotic neck dissection; SPRA, single-port robotic areolar; IONM, intraoperative neuromonitoring.

(R1) and after (R2) lobectomy, with electromyographic (EMG) signals recorded from the vocalis muscle via an endotracheal tube electrode. A recent systematic review suggests that IONM has high specificity for predicting postoperative vocal cord palsy, though its impact on the rate of permanent nerve injury remains debated [22].

Extension of IONM to the lateral neck permits monitoring of the spinal accessory nerve (SAN) and phrenic nerve in addition to the RLN and vagus nerve. In open MRND, SAN monitoring has been shown to be technically feasible and may reduce the incidence of postoperative shoulder dysfunction [23]. During robotic lateral neck dissection, IONM electrodes for the RLN are placed via the endotracheal tube as in

open surgery, while SAN monitoring can be achieved using surface electrodes on the trapezius muscle. Figure 1 summarizes the surgical access, lateral neck dissection sequence, and neuromonitoring targets for SP transaxillary robotic lateral neck dissection.

Ji et al. [24] reported on the feasibility and efficacy of IONM in remote-access robotic and endoscopic thyroidectomy, observing that complete standardized monitoring was more challenging than in open surgery, particularly during the early experience with transoral approaches. Continuous IONM, which provides real-time EMG feedback during dissection rather than intermittent stimulation, has been investigated in open thyroidectomy and may offer earlier detection of impending nerve injury from traction or

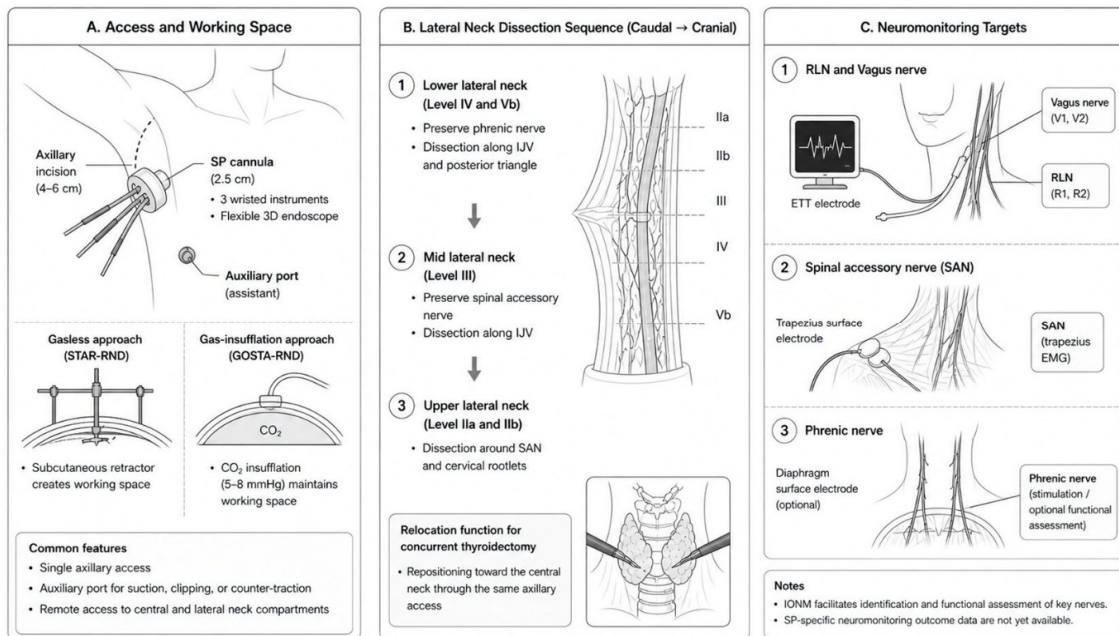


Figure 1. Surgical concept and neuromonitoring targets in SP transaxillary robotic lateral neck dissection. (A) The SP transaxillary approach uses a single axillary incision for introduction of the SP cannula, with an auxiliary port used for suction, clipping, or counter-traction. The operative space may be created using a gasless retractor system, as in STAR-RND, or maintained using low-pressure CO₂ insufflation, as in GOSTA-RND. (B) Lateral neck dissection is generally performed in a caudal-to-cranial sequence, beginning with the lower lateral neck, including levels IV and Vb, followed by level III and then the upper lateral neck, including levels IIa and IIb. When thyroidectomy is performed concurrently, the SP relocation function allows repositioning toward the central neck through the same axillary access. (C) Neuromonitoring may include standard V1–R1–R2–V2 monitoring of the vagus nerve and RLN using an ETT electrode, as well as extended monitoring of the SAN using trapezius surface electrodes. Phrenic nerve stimulation or optional functional assessment may be considered during lower lateral neck dissection, although standardized SP-specific neuromonitoring protocols and outcome data are not yet available. SP, single-port; 3D, three-dimensional; GOSTA-RND, gas-insufflation one-step single-port transaxillary robotic neck dissection; STAR-RND, single-port transaxillary robotic neck dissection; IJV, internal jugular vein; RLN, recurrent laryngeal nerve; EMG, electromyography; ETT, endotracheal tube; IONM, intraoperative neuromonitoring.

compression. Its application in robotic surgery remains limited by the need for a vagal electrode and the additional operative complexity.

No SP-specific IONM outcome data have been published to date. Therefore, current recommendations for neuromonitoring in SP transaxillary robotic lateral neck dissection are extrapolated from open thyroidectomy, open lateral neck dissection, and multiport remote-access robotic surgery. Although these principles are likely applicable, the narrower instrument corridor and single-cannula access may affect electrode placement and stimulation angles. Future work may also explore improved integration of EMG feed-

back into the robotic console, although this remains a technical goal rather than an established clinical tool.

Conclusion

SP transaxillary robotic lateral neck dissection using the da Vinci SP system is technically achievable, but it should currently be reserved for carefully selected patients in experienced centers. Early series demonstrate lateral lymph node yields and short-

term complication rates comparable to those of multiport robotic and open MRND, with the advantage of avoiding a cervical scar. However, the evidence base remains limited to small, retrospective, single-center Korean series with short follow-up, and the results should be interpreted with caution.

IONM is a valuable adjunct for nerve identification during robotic lateral neck dissection, although SP-specific outcome data are not yet available and its specific contribution to reducing permanent nerve injury in this setting has not been established. Standardized IONM protocols adapted for SP robotic access warrant further development.

Prospective multicenter studies with long-term oncologic follow-up, patient-reported outcomes, and cost-effectiveness analyses are needed before broader adoption of SP transaxillary robotic lateral neck dissection can be recommended.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Data Availability

None.

Author Contributions

All work was done by KK.

ORCID

Kwangsoon Kim <https://orcid.org/0000-0001-6403-6035>

References

1. Haugen BR, Alexander EK, Bible KC, Doherty GM, Mandel SJ, Nikiforov YE, et al. 2015 American Thyroid Association management guidelines for adult patients with thyroid nodules and differentiated thyroid cancer: the American Thyroid Association guidelines task force on thyroid nodules and differentiated thyroid cancer. *Thyroid* 2016;26:1–133. doi: 10.1089/thy.2015.0020
2. Ringel MD, Sosa JA, Baloch Z, Bischoff L, Bloom G, Brent GA, et al. 2025 American Thyroid Association management guidelines for adult patients with differentiated thyroid cancer. *Thyroid* 2025;35:841–985. doi: 10.1177/10507256251363120
3. Stack BC Jr, Ferris RL, Goldenberg D, Haymart M, Shaha A, Sheth S, et al. American Thyroid Association consensus review and statement regarding the anatomy, terminology, and rationale for lateral neck dissection in differentiated thyroid cancer. *Thyroid* 2012;22:501–8. doi: 10.1089/thy.2011.0312
4. Kim W, Yu HW, Kim SJ, Chai YJ, Choi JY, Lee KE. The anterior neck scar outcomes of conventional thyroidectomy using a wound protector: a multicenter double-blinded randomized controlled trial. *Int J Surg* 2024;110:3425–32. doi: 10.1097/JS9.0000000000001288
5. Kang SW, Jeong JJ, Yun JS, Sung TY, Lee SC, Lee YS, et al. Robot-assisted endoscopic surgery for thyroid cancer: experience with the first 100 patients. *Surg Endosc* 2009;23:2399–406. doi: 10.1007/s00464-009-0366-x
6. Kim JK, Lee CR, Kang SW, Jeong JJ, Nam KH, Chung WY. Robotic transaxillary lateral neck dissection for thyroid cancer: learning experience from 500 cases. *Surg Endosc* 2022;36:2436–44. doi: 10.1007/s00464-021-08526-7
7. Choi JY, Kang KH. Robotic modified radical neck dissection with bilateral axillo-breast approach. *Gland Surg* 2017;6:243–9. doi: 10.21037/gs.2017.06.09
8. U.S. Food and Drug Administration. 510(k) Premarket Notification. K173906: da Vinci SP Surgical System, EndoWrist SP Instruments, and Accessories. U.S. Food and Drug Administration; 2018.
9. U.S. Food and Drug Administration. 510(k) Premarket

- Notification. K182371: da Vinci SP Surgical System, EndoWrist SP Instruments, and Accessories. U.S. Food and Drug Administration; 2019.
10. Intuitive Surgical Inc. U.S. FDA clears da Vinci SP for certain transoral otolaryngology procedures. Intuitive Surgical, Inc.; 2019 [2026 May 3]. Available from: <https://investor.intuitivesurgical.com/news-releases/news-release-details/us-fda-clears-da-vinci-sp-certain-transoral-otolaryngology/>
 11. Kang SW, Chung WY. Transaxillary single-incision robotic neck dissection for metastatic thyroid cancer. *Gland Surg* 2015;4:388–96. doi: 10.3978/j.issn.2227-684X.2015.06.01
 12. Kim MJ, Lee J, Lee SG, Choi JB, Kim TH, Ban EJ, et al. Transaxillary robotic modified radical neck dissection: a 5-year assessment of operative and oncologic outcomes. *Surg Endosc* 2017;31:1599–606. doi: 10.1007/s00464-016-5146-9
 13. Kim K, Kang SW, Kim JK, Lee CR, Lee J, Jeong JJ, et al. Robotic transaxillary hemithyroidectomy using the da Vinci SP robotic system: initial experience with 10 consecutive cases. *Surg Innov* 2020; 27:256–64. doi: 10.1177/1553350620909279
 14. Kang IK, Park J, Bae JS, Kim JS, Kim K. Safety and feasibility of single-port trans-axillary robotic thyroidectomy: experience through consecutive 100 cases. *Medicina (Kaunas)* 2022;58:1486. doi: 10.3390/medicina58101486
 15. An S, Park J, Kim K, Bae JS, Kim JS. Safety and surgical outcomes of single-port trans-axillary robot-assisted thyroidectomy: experience from a consecutive series of 300 patients. *J Robot Surg* 2024;18:13. doi: 10.1007/s11701-023-01810-9
 16. Park J, Kang LK, Kim K, Bae JS, Kim JS. The learning curve for single-port transaxillary robotic thyroidectomy (SP-TART): experience through initial 50 cases of lobectomy. *Updates Surg* 2023;75:691–700. doi: 10.1007/s13304-022-01445-9
 17. Kim K. The evolution and clinical impact of single-port transaxillary robotic thyroidectomy: a comprehensive review. *Gland Surg* 2025;14:74–81. doi: 10.21037/gs-24-409
 18. Shin MH, Yin YK, Hwang H, Lee SM, Yi JW. First experience of Single Port Robotic Areolar (SPRA) thyroidectomy and Modified Radical Neck dissection (MRND). *Medicina (Kaunas)* 2025;61:1150. doi: 10.3390/medicina61071150
 19. Ho J, Kim D, Lee JE, Kim JK, Lee CR, Kang SW, et al. Single-port transaxillary robotic modified radical neck dissection (STAR-RND): initial experiences. *Laryngoscope* 2023;133:709–14. doi: 10.1002/lary.30437
 20. Chang YW, Ku D, Yu DY, Ko SY, Lee HY, Son GS. Robotic modified radical neck dissection for thyroid carcinoma using a gas-insufflation one-step single-port transaxillary (GOSTA) approach. *Asian J Surg* 2025;48:6684–90. doi: 10.1016/j.asjsur.2025.07.182
 21. Randolph GW, Dralle H, Abdullah H, Barczynski M, Bellantone R, Brauckhoff M, et al. Electrophysiologic recurrent laryngeal nerve monitoring during thyroid and parathyroid surgery: international standards guideline statement. *Laryngoscope* 2011;121 Suppl 1:S1–16. doi: 10.1002/lary.21119
 22. Kim DH, Kim SW, Hwang SH. Intraoperative neural monitoring for early vocal cord function assessment after thyroid surgery: a systematic review and meta-analysis. *World J Surg* 2021;45:3320–7. doi: 10.1007/s00268-021-06225-x
 23. Polistena A, Ranalli M, Avenia S, Lucchini R, Sanguinetti A, Galasse S, et al. The role of IONM in reducing the occurrence of shoulder syndrome following lateral neck dissection for thyroid cancer. *J Clin Med* 2021;10:4246. doi: 10.3390/jcm10184246
 24. Ji YB, Ko SH, Song CM, Sung ES, Lee BJ, Wu CW, et al. Feasibility and efficacy of intraoperative neural monitoring in remote access robotic and endoscopic thyroidectomy. *Oral Oncol* 2020;103:104617. doi: 10.1016/j.oraloncology.2020.104617